## Rate Laws

# What is the general relationship between the value of the specific rate constant, *k*, and the speed of a chemical reaction?







The **rate law** is an expression for the rate of a reaction in terms of the concentration of reactants.

The **specific rate constant** (*k*) for a reaction is a proportionality constant relating the concentrations of reactants to the rate of the reaction.

$aA \rightleftharpoons cC$

$\text{Rate} = k[A]^a$

$$\text{Rate} = k[\text{A}]^a[\text{B}]^b$$

for $aA + bB \rightleftharpoons cC + dD$

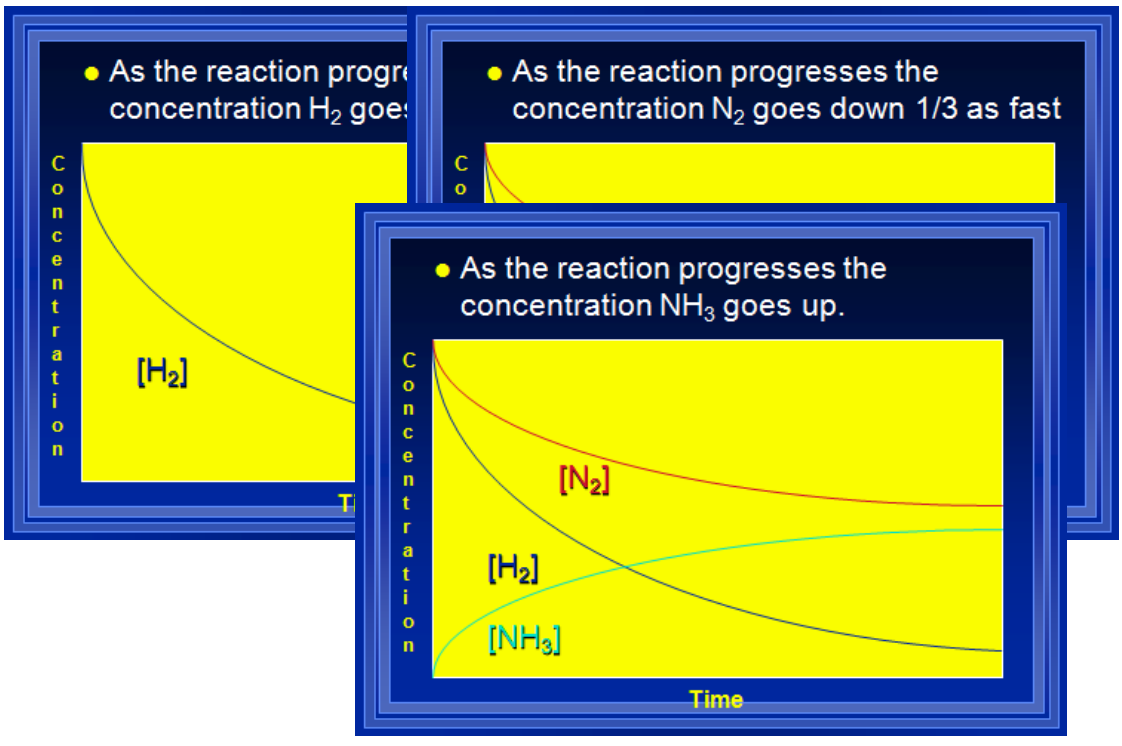
- The value of the specific rate constant, *k*, is large if the products form quickly; the value is small if the products form slowly.

## Kinetics

- The study of reaction rates.
- Spontaneous reactions are reactions that will happen - but we can't tell how fast.
- Diamond will spontaneously turn to graphite – eventually.
- Reaction mechanism- the steps by which a reaction takes place.

## Reaction Rate

- Change in concentration per un
- $N_2 + 3H_2 \longrightarrow 2NH_3$



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| | |
|---|---|
| A ⟶ products | Rate = k[A] |
| A+A ⟶ products | Rate= k[A]$^2$ |
| 2A ⟶ products | Rate= k[A]$^2$ |
| A+B ⟶ products | Rate= k[A][B] |
| A+A+B ⟶ Products | Rate= k[A]$^2$[B] |
| 2A+B ⟶ Products | Rate= k[A]$^2$[B] |
| A+B+C ⟶ Products | Rate= k[A][B][C] |

## Formed in reversible reactions

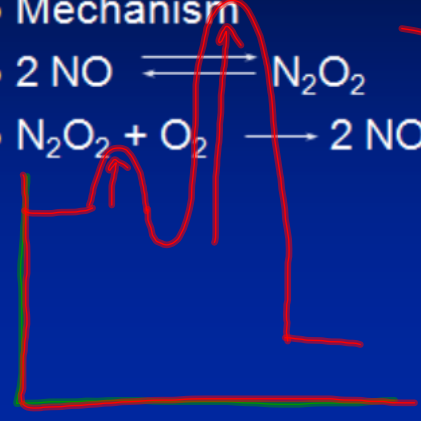
- $2\,NO + O_2 \longrightarrow 2\,NO_2$
- Mechanism
- $2\,NO \rightleftharpoons N_2O_2$ (fast)
- $N_2O_2 + O_2 \longrightarrow 2\,NO_2$ (slow)

EXO

ΔH = −

2 steps

2 elementary steps

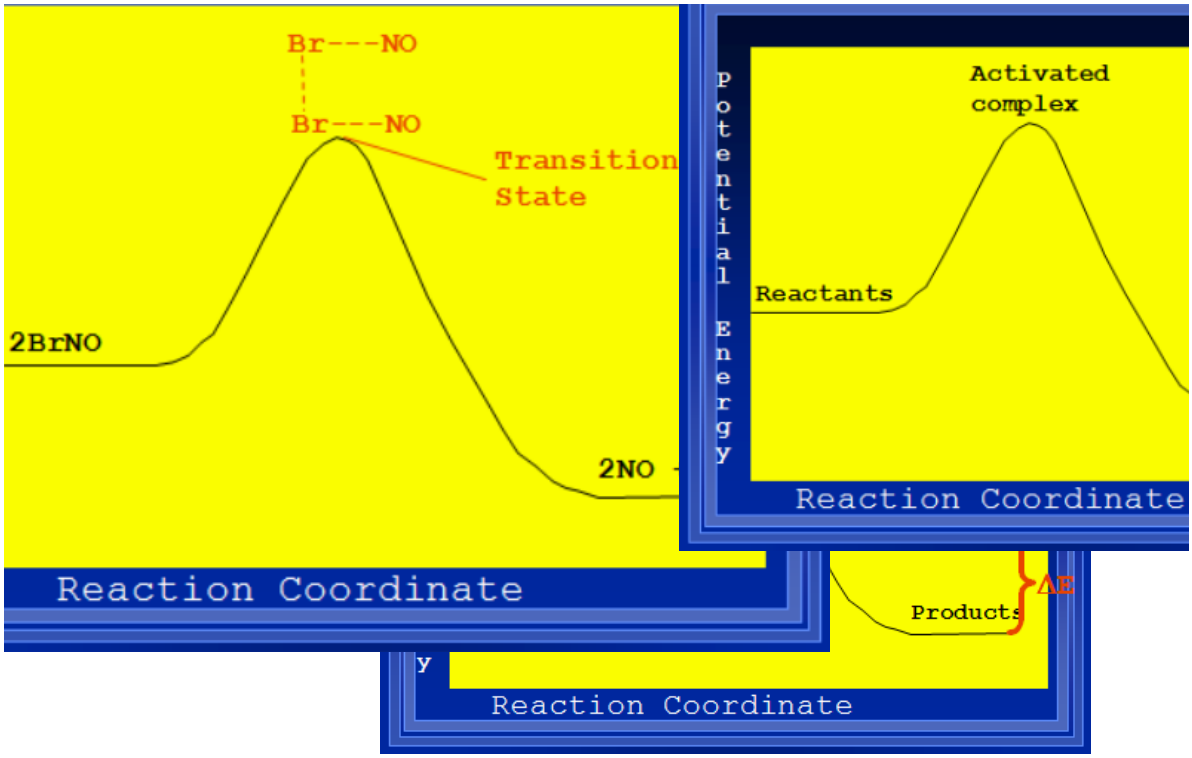


rate determing step (slowest step)

- 2 IBr
- Mechani
- IBr
- IBr + Br
- I + I

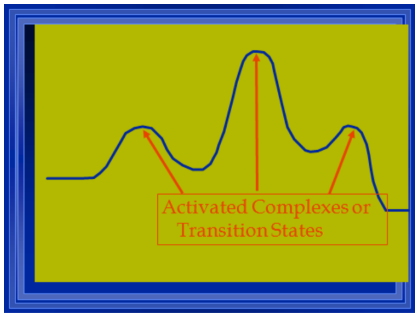
# Collision theory

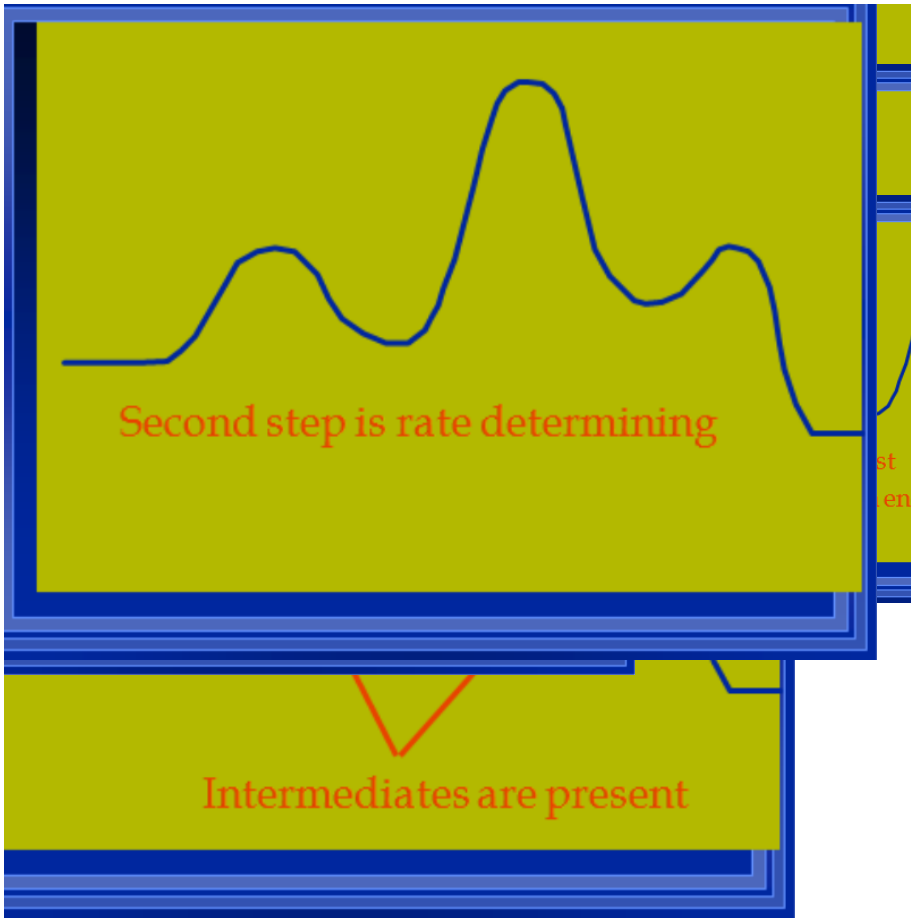
- Molecules must collide to react.
- Concentration affects rates because collisions are more likely.
- Must collide hard enough.
- Temperature and rate are related.
- Only a small number of collisions produce reactions.

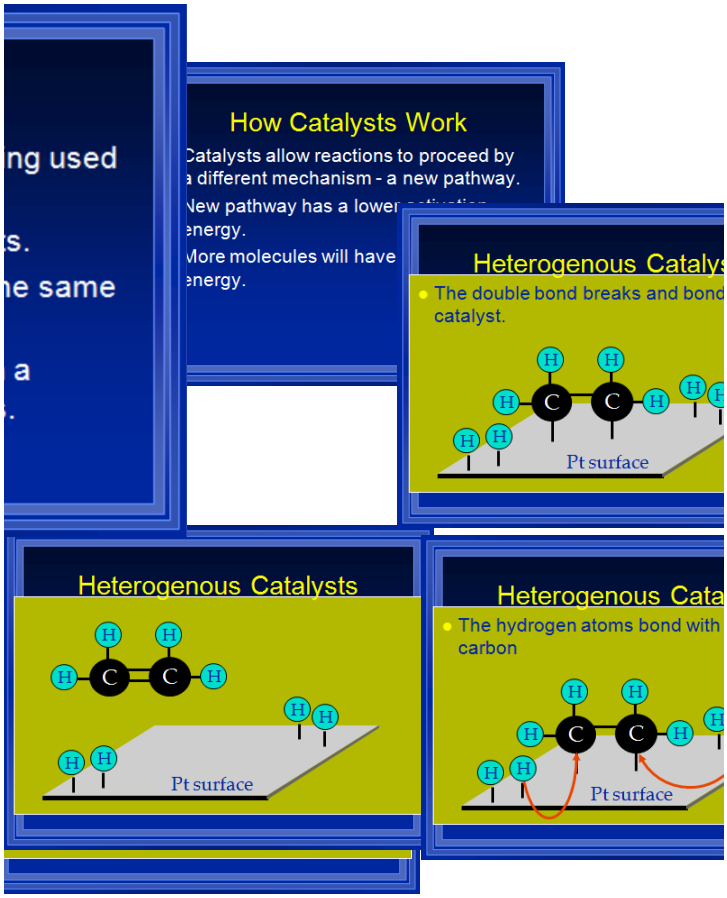


## Terms

- Activation energy - the minimum energy needed to make a reaction happen.
- Activated Complex or Transition State - The arrangement of atoms at the top of the energy barrier.








## Animation 24

Observe the characteristics of a first-order reaction.

In a **first-order reaction**, the reaction rate is directly proportional to the concentration of only one reactant. As the concentration of that reactant decreases, the rate of the reaction also decreases.

$1A \rightleftharpoons C$

$Rate = k[A]^1$

$1A + 1B \rightleftharpoons$

$Rate = k[A]^1[B]^1$

$y = x^2$





**Practice Problems for Conceptual Problem**

**36.** Show that the unit of $k$ for a first-order reaction is a reciprocal unit of time, such as a reciprocal second ($s^{-1}$).

ChemASAP click to start

**Problem Solving 18.36**
**Solve Problem 36 with the help of an interactive**

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## Reaction Mechanisms

# What do the hills and valleys in a reaction progress curve represent?

An **elementary reaction** is a reaction in which reactants are converted to products in a single step.

reaction step(s)

The series of elementary reactions or steps that take place during the course of a complex reaction is called a **reaction mechanism**.





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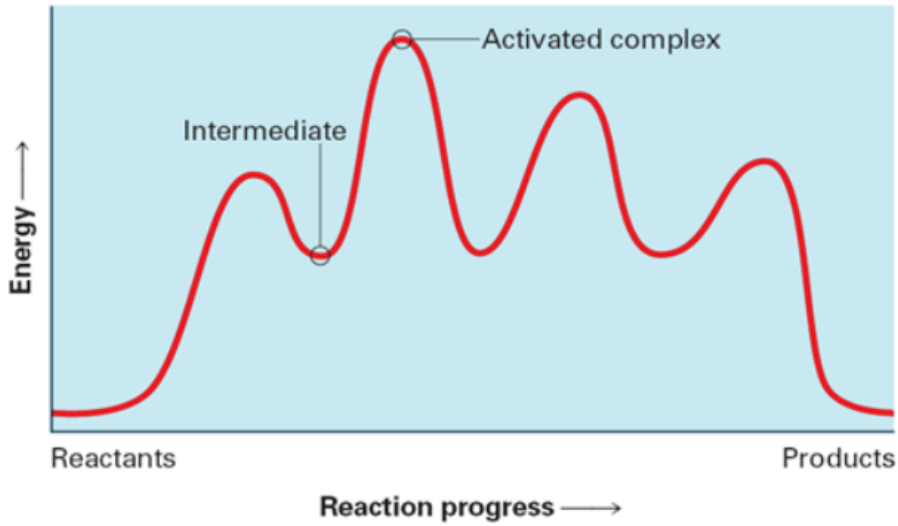
**An intermediate is a product of one of the steps**

and then it is used in the next step.

## Energy Changes for a Multi-Step Reaction










**The peaks correspond to the energies of the activated complexes. Each valley corresponds to the energy of an intermediate.**